

Information Wizardry: A six-week course for practicing veterinarians in improving clinical decision-making

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ABSTRACT

INTRODUCTION: The veterinary medical practitioner has a responsibility to offer the highest quality medical services based on the best evidence-based medical information available. Practitioners may benefit from CE courses that help them to critically read the scientific literature and apply information to their practice.

OBJECTIVES: To strengthen evidence-based veterinary medicine (EBVM) practices using a CE course that focused on critical understanding and application of biostatistics and epidemiology.

METHODS: The 12 hour free CE course used a modified flipped classroom approach, to better engage students in discussion of prepared materials. All teaching materials, assignments and class discussions relied on veterinary medical examples exclusively. We measured participants' ability to understand and critique statistical and epidemiological measures of peer-reviewed published veterinary medical literature by their performance on pre- and post-course tests. An on-line evaluation survey administered after the course measured the extent to which the participants' (1) thought the course would change the way they read the veterinary medical literature and practiced veterinary medicine, (2) evaluated their experiences with the course, and (3) assessed the extent to which various features of the course would affect future decisions to take the course.

RESULTS: Forty-eight clinicians registered; 12 became full-time course participants. Mean posttest score for all 12 participants was significantly higher than the pretest score. Participants' estimation of their ability to critique statistical and epidemiological measures of peer-reviewed, published literature was considerably higher after the course than before the course. On a scale of 1 to 5, the mean score for participants' expectations that taking the course would change their reading of the veterinary medical literature was 4.42 and for changing the way they practiced veterinary medicine was 2.67.

CONCLUSION: CE courses that incorporate significant face-to-face interaction between participants and instructors using a flipped classroom model should be offered routinely to practicing veterinarians as a way of improving EBVM practice.

KEYWORDS — continuing education | curricula | curriculum delivery | epidemiological concepts | evidence-based veterinary medicine | flipped-classroom methods | information wizardry | statistical concepts | veterinary medical practitioner

ABBREVIATIONS — EBVM: Evidence-based Veterinary Medicine; H_0 : Null Hypothesis; H_a : Alternative Hypothesis; CE: Continuing Education; MVMA: Massachusetts Veterinary Medical Association; JAVMA: Journal of the American Veterinary Medical Association; SD: Standard Deviation

Introduction

*“...it was obvious that this was probably the single most practically helpful C.E. event I have taken in 16 years, and that it could easily have lasted all summer or be offered in several modules”**

**Written evaluation comment from course participant*

The veterinary medical practitioner has a professional and ethical responsibility to offer clients and their animals the highest quality medical advice and services available at the time an animal is presented for medical and wellness care. To meet this responsibility, veterinary medical curricula require students to study some combination of biostatistics, epidemiology and population (including public) health and to apply their knowledge of these topics to improve the health of individual animals, animal populations and also the health of clients and the public. Veterinarians engaged in veterinary medical practice may then reinforce

Significance

We proposed to investigate the effectiveness of the course by testing two hypotheses:

1. H_0 : Completing the CE module will have no measurable effect on veterinarians' ability to critique statistical and epidemiological measures of peer-reviewed, published literature (H_a : completing the course will have a measurable effect);
2. H_0 : Completing the CE module will have no measurable impact on participating veterinarians' clinical practice (H_a : completing the module will cause a measurable improvement in practice).

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evidence-based applications by reading peer-reviewed veterinary medical journals and attending conferences that offer continuing education credits.

The quality of evidence-based practice thus relies upon three critical control points:

1. The extent to which veterinary medical students learn evidence-based concepts and principles.
2. The quality of scientific publications as determined by the peer review process and of other sources of scientific information, such as continuing education sessions.
3. The extent to which clinicians read, critique, comprehend and apply evidence-based concepts and principles in their practices, including from the scientific literature and continuing education (CE) sessions.

In these respects, the expectations for veterinary medicine do not differ from the practice of human medicine.

This report summarizes the development, implementation and evaluation of a continuing education course that addressed the third critical control point, improving the ability of veterinarians to critically read the scientific literature by filling gaps in their understanding and application of important concepts in statistics and epidemiology, including the hierarchy of evidence, Bayes theorem, and meta-analysis.

The objective of the course was to strengthen evidence-based veterinary medicine (EBVM) practice through critical understanding and application of biostatistics and epidemiology.

Methods and approach to course development & data analysis

Recruitment. We intended to use the sampling frame of approximately 2,000 veterinarians in Massachusetts obtained from the Massachusetts Veterinary Medical Association (MVMA), supplemented with all available yellow page directories for the State of Massachusetts, to generate a random sample of 40 practicing veterinarians[1]. We decided early on, however, that updating this list and generating the sample was too labor-intensive without student assistance and, for that reason, we elected to announce the availability of this course in three ways, all with the assistance of the MVMA. The organization sent an announcement (Appendix 1) to all MVMA members using electronic mail, placed an insert announcing the course in the March edition of the MVMA newsletter, and posted flyers at the spring MVMA continuing education conference. The text of all three documents was the same. Interested individuals were referred to Susan Brogan, Director of Continuing Education, Tufts Cummings School of Veterinary Medicine (TCSVM), for additional information and to register for the course.

Curriculum Development. We used several resources as starting points for curriculum development: our own experiences teaching biostatistics and epidemiology to veterinary medical students, the teaching materials we developed for those courses, and an Information Mastery curriculum¹ developed by Allen F. Shaughnessy, PharmD, MMedEd of Tufts University, and David Slawson, MD, of the University of Virginia, and delivered routinely to Tufts Medical School residents by Dr. Shaughnessy.

Because we were limited to teaching our course in 12 hours (not including outside assignments completed by participants), we adopted several concepts from the Information Mastery course, adapted them for veterinarians, and added concepts that we thought were important for veterinary clinicians to address (including, for example, Bayes theorem and meta-analysis). We received approval from the MVMA to offer the course for 12 continuing education credits.

Course Delivery. Again, we relied on our own experiences with curriculum delivery using both traditional and **flipped classroom**² methods, to determine course delivery[2]. Compared to traditional teaching methods, where instructors deliver information to students who are asked to carry out homework assignments based on that information, the flipped classroom asks students to prepare for a classroom session in a variety of ways — by reading assigned materials, viewing video clips, slide presentations, and the like, prior to class. During classes, instructors employ methods that actively engage students in discussion of prepared materials, and instructors serve as facilitators of those discussions.

We also received valuable guidance in course delivery from Haejung Chung, Senior Education Technology Specialist, Tufts Technology Services, and a Tufts Medical School colleague, Dr. Misha Eliasziw, PhD, MSc, HBS, Associate Professor of Public Health and Community Medicine, who has successfully implemented flipped classroom methods in the biostatistics courses she teaches.

We identified opportunities within the curriculum to apply **spacing and interleaving**, two techniques that have been shown to improve retention of learned material by course attendees[4][5]. The former involves repetition of material at predetermined intervals during the course, and the latter involves presenting various aspects of topical themes in combination rather than focusing on single topics in sequential fashion. For example, to practice interleaving, instructors led class discussions of many scientific papers in most classes that simultaneously highlighted several concepts emphasized in the course, for instance, hierarchy of evidence, study design, reference intervals, and measures of significance.

We used examples *solely* from clinical veterinary medicine. Where we found examples we wished to use in the human medical literature we replaced them with examples from the veterinary medical literature to make the course as relevant as possible to participants. We also explored, and used, multiple methods of learning—quizzes at the beginning of classes to reinforce concepts derived from assigned preparatory material, brief reviews of material covered in the previous class, small group work, whole class discussions, and video clips that were chosen for their ability to teach difficult concepts in simple, short and entertaining ways. We used the *Two Ronnies* video[3] to illustrate how prior information (whether one is in a hardware or a candle store) influences interpretation of the question and the outcome (whether one is given a fork handle or four candles — Bayes theorem and the application

¹Center for Information Mastery @ <http://medicine.tufts.edu/Education/Academic-Departments/Clinical-Departments/Family-Medicine/Center-for-Information-Mastery>

²Flipped Classroom (Wikipedia): http://en.wikipedia.org/wiki/Flipped_classroom

of prior knowledge), not just the importance of clear, consistent and well-defined terminology.

We set up a course website on Tufts University’s Trunk³, an online learning environment powered by Sakai⁴ and tailored to facilitate teaching, learning, and assessment (Figures 1 and 2). Trunk hosts course management sites and serves all Tufts health sciences schools and programs including the Medical, Dental and Veterinary Medical Schools. All registered veterinarians were assigned a Trunk account by Tufts Information Technology Services so they could access the course site. The site was used to store and make available to participants all course content and resources, the student roster, and to send group e-mails and announcements to participants. Students were introduced to using Trunk when they were asked to each write a brief biographical sketch similar to the ones provided by the instructors and to post their biosketches on Trunk.

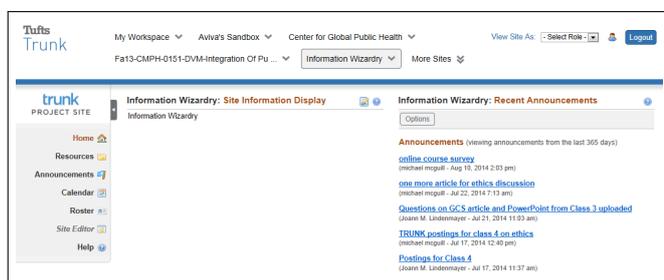


Figure 1: Information Wizardry course management main page on Trunk

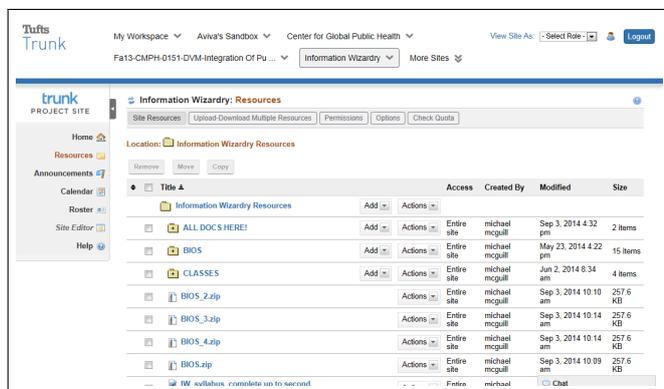


Figure 2: Information Wizardry child page

We selected four dates for course delivery (4 June, 18 June, 9 July and 23 July 2014), each one on a Wednesday evening from 6:00 pm to 9:00 pm to suit work schedules of course participants. We separated each class by two to three weeks so that participants would have time to review assigned readings, videos and homework assignment questions. Spacing information out also supported reinforcement of information covered in previous lessons (the spacing technique). Meals were offered at each class.

Participants were also asked to take a quiz at the beginning of each session except the first. These were designed to reinforce understanding of readings given for homework assignments and to help participants identify gaps in their understanding of material;

participants were encouraged to discuss answers but were not required to share answers with or turn them in to course instructors.

Measures of Course Effectiveness

Course effectiveness was measured with a pre- and post-course test and a course evaluation.

Participant's Test Performance. Course organizers measured participants’ ability to understand and critique statistical and epidemiological measures of peer-reviewed published veterinary medical literature by comparing participants’ performance on a test that was administered at the beginning of the first class and at the end of the last class. We devised a 15 question test; 14 multiple-choice questions reflected the main concepts covered by the curriculum.

The 14 questions asked about the following concepts:

1. Reference intervals
2. Diagnostic vs. screening tests
3. Sensitivity and specificity of a diagnostic test
4. Predictive value positive
5. Confidence intervals
6. Predictive value positive vs. predictive value negative
7. Hierarchy of evidence
8. T-tests vs. tests of a proportion
9. Definition of a statistic
10. Bayes theorem
11. Meta-analysis
12. Types of variables
13. Descriptive statistics
14. Graphing data (histogram)

Question No. 15 asked, in a humorous way, about self-reported confidence in their ability to critique scientific publications:

“How much of an Information Wizard do you consider yourself to be today?”

Possible answers included:

1. “Not at all (I haven’t read a single Harry Potter book)”
2. “A little bit of a Wiz (I’ve seen ‘The Wizard of Oz’ at least once)”
3. “A good Wiz (I perform levitation from time to time)”
4. “A great Wiz (I am Gandalf).”

³Tufts University Trunk Learning Management System (LMS) @ <https://trunk.tufts.edu>

⁴The Sakai Project @ <https://sakaiproject.org>

Course Evaluation Survey. We created an online survey using the Tufts University Qualtrics survey tool[6]. The survey had *three goals*.

The first goal was to assess, using a scale of 1 to 5 and an open-ended question, the extent to which participant’s thought having taken the course would change, (1) the way they read the veterinary medical literature, and (2) the way they practice veterinary medicine. The following questions addressed this goal:

1. To what extent do you think having taken the course will change the way you read veterinary medical literature? (scale of 1 to 5, 1= not at all, 5 = completely):
 - a. Please explain how you think it will change the way you read the literature (open-ended).

2. To what extent do you think having taken the course will change the way you practice veterinary medicine? (scale of 1 to 5, 1= not at all, 5 = completely):
 - a. Please explain how you think it will change your practice (open-ended).

The second goal was to evaluate participants’ experiences with the course. Questions that addressed this goal used a variety of response formats – *Likert scale, yes/no/unsure* and *open-ended*.

The third goal was to assess the extent to which various features of the course – cost, in-person discussion format and the like, contributed to participants’ decision to take the course and whether these features would affect future decisions to take the course.

At the conclusion of the course a link to the survey was sent to each participant by a third party so that we could assure participants that they would not be matched with their comments.

Participants were informed that they would receive their CE certificates when they had completed the survey.

Data analysis.

To preserve participants’ anonymity, pre-course tests were numbered sequentially and participants were asked to save their test number so that they could match the number on their post-course tests. At the conclusion of the course eight of 12 participants were able to recall or locate the number of their pre-course tests.

Differences in the percent of correct responses for all 12 students (questions 1-14) from pre-course to post-course tests were analyzed using *unpaired t-tests*. Differences in the percent of correct responses by participant for the eight paired pre- and post-tests were analyzed using a *paired t-test*. Answers that were left blank were classified as incorrect. A cutoff of $\alpha=0.05$ was used to ascertain statistical significance.

Results

Sample Population. Forty-two (42) veterinarians expressed interest in attending the course. Of those, 28 registered for the course. Of those who registered, 14 attended the first class, 12 in person. Two additional individuals attempted to attend by Skype®, one individual who was not ambulatory and another who was unable to attend the first class in person. Despite repeated attempts and the assistance of the Director of Continuing Education, we were unable to establish a

functional link with the latter two individuals and reluctantly dropped them from the course roster.

Curriculum content and methods of delivery. The content for each class as well as assignments (readings and videos) and structure for each class are all included in the syllabus (Appendix B).

Comparison of pre-and post-test results by participants. The pre-test mean score for all 12 participants was 39.9% (SD 9.4), the post-test was 52.4% (SD 15.6), and the mean difference of 12.5% was statistically significant at our predetermined cutoff of $\alpha=0.05$, (95%) CI [1.6, 23.4], $p = 0.026$. For the eight participants whose pre- and post-test scores were paired, the pre-test mean score was 40.2% (SD 11.4), for the post-test was 56.3% (SD 17.7), and the mean difference of 16.1 was not statistically significant at our predetermined cutoff of $\alpha=0.05$, 95% CI [0.44, 32.56], $p = 0.055$.

Comparison of pre- and post-test answers, by question. The only significant difference between pre-and post-test answers by question was the one that asked about Bayes theorem⁵, although had we corrected for multiple comparisons this would not have been considered significant (Figure 3).

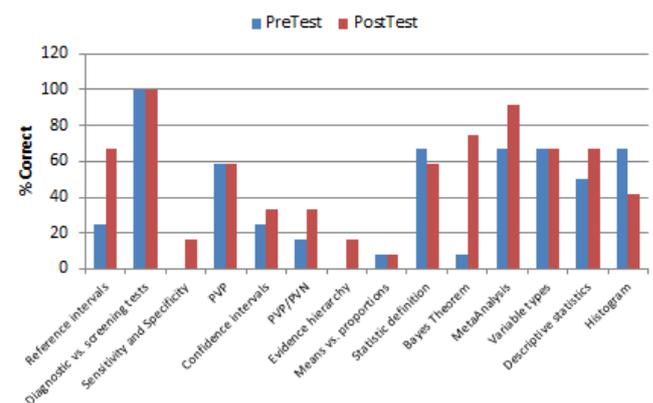


Figure 3: Pre- and post-test comparison of responses to question concepts, for all participants [n=14]

When comparing pre- and post-test self-reported confidence in critiquing veterinary medical literature, participants reported that confidence in their ability to be an “Information Wizard” increased at the conclusion of the course (Table 1). Before taking the course, 58.3% reported they were “Not at all” an Information Wizard, and 41.7% answered they were “A little bit of a Wiz.” After the course, 75% reported they were “a little bit of a Wiz” and 25% reported they were “a good Wiz” (Table 1).

Course evaluation. The course evaluation was designed to evaluate anticipated changes to 1) reading the veterinary medical literature, and 2) practicing veterinary medicine.

The mean score for participants’ expectations that having taken the course would change the way they read veterinary medical literature was 4.42 (on a scale of 1 to 5); the mean score for their expectations that having taken the course would change the way they practiced

⁵Bayes Theorem @ http://en.wikipedia.org/wiki/Bayes'_theorem

Table 1: Pre- and post-course comparison of self-reported level of Information Wizardry

	Number of Responses Before Course (%)	Number of Responses After Course (%)
Not at all	7 (58.3)	---
A little bit of a Wiz	5 (41.7)	9 (75.0)
A good Wiz	---	3 (25.0)
A great Wiz	---	---

Table 2: Responses to the question "Please explain how [having taken the course] will change the way you read the literature." [n=9]

"Generally I would read the abstract and conclusions and not really consider the structure of the paper. Yes, I'd note if it was a single case, double blind retrospective or whatever, but now I will be far more critical as to whether the conclusions are valid, the study conducted properly, etc., Of course it will mean I can read far less in the same amount of time, but I will be far more critical than I was, and I've always been skeptical of much of what is in the literature."

"I am now very skeptical of the relevance of what I read in JAVMA in particular. Also I frequently peruse the literature to see what is new in human medicine - now, I have been looking for meta-analyses and reviews, and I understand how very difficult it is to get much information from a single study and how difficult it is to design a study - so most of them are suspect."

"I will look at most conclusions with more skepticism. I will also pay more attention to the quality of the study itself and not just the results."

"I think I will be more thorough in reading research papers and more skeptical about what authors report." "More critical of the papers published and a closer look at the data and sponsors."

"More critical of the papers published and a closer look at the data and sponsors."

"I will have a greater understanding of the ways authors can manipulate the data to achieve the desired outcome. I will be more critical as I am reading and not just skim the results/conclusions."

"I now understand that my own critical view and skepticism of the literature is shared by others in the field, and feel empowered to maintain that approach, with a clearer, more educated eye as to why we must be so critical."

"I will take a little more time reading articles, looking at the data, statistics, and graphs presented."

veterinary medicine was 2.67 (on a scale of 1 to 5).

Tables 2 and 3 describe how participants thought having taken the course would change the way they read the veterinary medical literature [n=9] and how they practice veterinary medicine [n=7], respectively. Almost every respondent reported that s/he would be more critical of reading published papers and would be more skeptical of author's conclusions. In general, respondents noted that they would be less likely to rely on a single study to decide whether to change a practice or not, but that they would also depend on evidence from clinical signs, other studies and colleagues' advice.

Participants' experiences with the course. Participants were asked to respond to questions about their experiences with the course. Mean scores for all questions were high (4.08 on a scale of 1 to 5) with the

Table 3: Responses to the question "Please explain how [having taken the course] will change the way you practice veterinary medicine." [n=7]

"I have always based diagnosis more on what I see than on test results which don't mirror what I am seeing clinically, but I will be far more critical of the tests run and seek to determine if they are the most appropriate."

"I never much changed what I did based on single articles.,Now more than ever I think I am right not to have ever really been an "early adopter" of many things. I will continue to wait for robust evidence before I change the things I do. I also have relied on my C.E. meetings and trust what I learn there, so I'm not pig-headed about it."

"I will look at data more objectively."

"I don't think I will be as likely to accept new methods of practice on the basis of a single study."

"I will more discerning of what will affect my practice."

"Not much."

"I think I will contact my colleagues more frequently for advice when information presented in articles is equivocal!"

Table 4: Mean scores for questions about the effectiveness of the course.

	Mean
To what extent did the course meet your expectations?	4.42
Did the course achieve its learning objectives?	4.08
Were the dates and times of classes convenient?	4.50
Did you have adequate time to prepare for each class?	3.42
Did readings and videos help you understand concepts?	4.25

exception of "Did you have adequate time to prepare for each class?" which was lower (Table 4).

Of all 12 participants, 11 (91%) responded that they would recommend the course to a colleague; one individual was not sure.

When asked to identify the three best features of the course, most respondents mentioned the classroom discussions/interactions with colleagues as the best feature. Other features that were noted frequently were the instructor expertise and enthusiasm and course content (Table 5).

When asked to identify the three worst features of the course, most respondents commented that it seemed frequently disorganized, and several noted that using Skype and Trunk posed challenges. Comments on time included remarks that there was not enough time, or that too much time was required for adequate preparation (Table 6).

Participants were asked for their suggestions for improving the course. Participants suggested better organization and timing, and more guidance — providing a study guide, practice problems and a rubric for evaluating papers (Table 7).

Reasons for taking the course. This course incorporated several features that are not found in typical CE courses. Participants rated their desire to improve mastery of veterinary medical information as their main reason for taking it. Free food was rated the least important factor affecting participants' decision to take the course (Table 8).

Since we anticipated offering the course in online modules for the future, we asked participants how likely they'd be to take it if formats different from in-class discussions were available. Only formats with

Table 5: The three best features of the course, mentioned by participants.

"[John] Ioannides papers"	"Group discussions"	"The material in general was well chosen and easy to understand, but really explained the concepts."
"The materials you put online for us. Good to print and keep"	"The evening, summer format was over-the-top fabulous - a great change!"	"The review of statistics."
"The subject matter"	"Free CE"	"Trunk"
"The interaction with other participants"	"The clear expertise of the instructors"	"The intriguing nature of the subject."
"Interaction with fellow course attendees"	"Discussion of clinically relevant topics"	"Enthusiasm of instructors."
"Extremely wonderful instructors"	"Good information discussed in class"	"Interaction and discussion with classmates."
"The group setting"	"The interactions"	"Time and location."
"Class discussions"	"Learning new ways of interpreting the literature"	"Having veterinarians from so many different fields of practice come together as a united front and agree on the topics at hand."
"The interactive nature of it"	"The fact that we had to use critical thinking skills (unlike other CE's)"	"The concepts were very readily applicable to the way I practice."
"It was relevant to my every day practice"	"It was a great group of veterinarians to learn with"	"I like statistics and data analysis."
"Discussion groups"	"Subject matter"	"2 instructors."
"Discussions and questions and interaction"	"The utilization of Trunk"	"Dinner."

some or all face-to-face interactions with instructors and/or fellow students were favored (Table 9).

Seven participants (55%) stated they would sign up for the course if a registration fee were required, and of four who offered an amount s/he would be willing to pay for the course, one offered \$100, one \$125, and one \$150; one individual offered \$1,000 for a summer-long course.

Finally, participants were offered the opportunity to share additional comments with course instructors (Table 10).

Discussion

We tested the null hypothesis that completing the CE module would have no measurable effect on veterinarians' ability to critique statistical and epidemiological measures of peer-reviewed, published literature by evaluating their performance on pre-and post-course tests. Mean performance (unpaired) of all participants on the test was significantly higher at the end of the course compared to before the course began, but mean performance for the eight participants whose tests

Table 6: The three worst features of the course, mentioned by participants. (*NB: All twelve students attended the first and last classes, so this comment does not make sense to the course instructors.)

1	2	3
"Sometimes it was a bit disorganized."	"Lot of material to cover and could have been at least a week longer."	"Wish Mike had had a [mic] as he was often hard to hear."
"That the readings were posted so soon before class."	"Sometimes it was hard to grasp the more difficult concepts at 9:00 p.m."	"Skype. Skip it."
"IT problems."	"The class was frequently disorganized."	"The instructors often times had trouble explaining the concepts."
"Technological challenges."	"Lack of organization."	"Time management issues."
"Sometimes late uploading/notification of materials."	"Trunk is less than optimally user-friendly."	"A bit disorganized, but who am I to criticize *that*?"
"The electronics did not work sometimes."	"None."	"None."
"The timeliness of materials sent out to read before class."	"Appeared disorganized at times."	"Can't think of a third."
"Statistics itself is boring to me."	"Occasional disorganization of instruction (but understandable, considering newness of attempts at putting course together)."	"Not completely clear as to if we accomplished course objectives from point of view of instructors."
"The IT troubles!"	"Sometimes we had to rush through things in the interest of time."	"The quizzes at the beginning of the class added a stress element."
"I would have liked more of an outline of the course on the first day."	"I thought we should have gotten our assignments for the next class the same day or the day after the previous class."	"It seemed like we jumped around between topics sometimes."
"Online attempt during first class."	"That I wasn't able to come to last class." *	
"Some of the topics were difficult to grasp."	"Time commitment"	

could be paired, though higher at the end, did not differ significantly between the two testing periods. In both cases confidence intervals on the mean differences pre- and post-course tests were wide, likely reflecting the fact that the number of participants was small.

In hindsight, a better way to measure this hypothesis might have been to use a technique that these instructors have used in their biostatistics and epidemiology courses, namely, by assigning participants 2-3 papers several weeks prior to the last class, encouraging them to critique those papers according to concepts presented in class and to use any means at their disposal, including group discussion, and then test them on those papers at the conclusion of the course. Were we

Table 7: Participants' suggestions for improving the course.

"Having more classes. Better organization, sometimes it seemed both Mike and Joann were speaking extemporaneously and hadn't thought through how best to explain some of the trickier concepts. We always were way behind on our schedule and didn't get to discuss some of the stuff that was really fascinating."
"There was an awful lot to cover in 12 hours. It should be a longer course, or maybe the subject could be covered in a few courses such as Wizardry I, Wizardry II etc. That way, you could truly prescribe readings, quiz, discuss, reinforce through group exercises, discrete topics. Sometimes it seemed like there was so much information, that it was actually not reinforced all that great and the topics were all over the place. Not to say I didn't get a lot out of it all and learned a ton...I guess I just didn't realize statistics could be so interesting and just wish the course were longer."
"YES: 1. The instructors need to collaborate more to make it seem like one course. 2: The first two classes should be set up as a class room review of the concepts. For most of us, we hadn't seen these concepts in 20 years. 3. The remaining 2-4 classes should be set up to go over cases and real-life concept examples. 4. It's obvious that the instructors know the concepts. They need some assistance in making them accessible to seasoned clinicians."
"If the class were slightly better organized, I think that would help. We really didn't have enough time to cover everything we needed to cover. In addition, a little more time in the first and second sessions to explain concepts more clearly will help instructors and participants see the relevance to the third and final session better."
"I expect that subsequent iterations of the course will likely run a bit more smoothly. The shakedown cruise is always a bit rough."
"I thought the class was great."
"Better organization, perhaps a reading list distributed on the first day of class so we can make time to do the necessary reading."
"Not really. Practice makes perfect."
"I think the timing issues and IT problems will improve if it is taught again and again."
"Yes. Just more of an outline on what will be covered in each class and especially what to focus on to prepare for the quizzes. Also, a study guide with practice problems to review the statistics. I would have learned better by just having an assignment of math problems to do at home prior to the class."
"I would have liked-when given papers to have some more instruction on what I should be looking for."
"Not at this time."

Table 8: Mean scores for questions contributing to participants' decision to take the course.

How much did each of the following features contribute to your decision to take the course?	Mean
Free CE Credits	3.09
Free food	1.73
Convenient times	4.18
Didn't have to travel far	3.64
Wanted to improve mastery of medical information	4.55

or others to repeat teaching this course again, we recommend that a methodology be developed for judging participants' ability to critique the papers.

One way to accomplish this would be to convene an expert panel

Table 9: Mean scores for questions about likelihood of taking the course using different formats.

How likely would you be to take the course if the format was...?	Mean
A self-taught online module with no interaction with instructors or fellow students	1.75
An online module with limited interaction with instructors or fellow students	2.33
A combination of online self-instruction and face-to-face interaction with instructors and/or fellow students	3.75
Didn't have to travel far	3.64
Only face to face with instructors and fellow students	4.58

Table 10: Additional comments offered by participants.

"I went in not really knowing what to expect and thoroughly loved the experience. Some of the very best CE I have ever done and it really made me think and participate rather than just sit and listen. I met a great group of local veterinarians too."
"It wasn't the free credits that appealed to me - it was that I could earn 12 all at once without having to go away to a conference, pertaining to a single topic that was really interesting. And then, further into the course it was obvious that this was probably the single most practically helpful C.E. event I have taken in 16 years, and that it could easily have lasted all summer or be offered in several modules. Critical thinking is very important to us as practitioners. This class made me a better vet than so many of the others of a "how to" nature. Also, the multiple-evening format was great for me as a self-employed vet. Not much time to go away for a day or week at a time. If you do the course in the evening again, offering a light meal is a really great idea because participants don't have to worry about eating prior to class at the end of a busy day. Very practical. Thanks for the opportunity to take this wonderful class."
"I loved the class. I would be interested in attending more of these if the opportunity arose. The format does need some tweaking."
"It was a lot of fun, thanks for doing this!"
"Overall, it was a thoroughly enjoyable experience for which I am grateful to Tufts and Joann, Mike, and Susan [Brogan, the Director of CE at the Cummings School]."
"Go Dragon Boats! (One of the instructors races dragon boats competitively.)"
"Overall - good class, good group, and good instructors."
"I liked the class discussions the best. I felt these were the most helpful, fun, and interesting times in the class! Thank you for offering the course."
"I had absolutely no idea what the class would be like. I signed up more out of curiosity than any other reason. I enjoyed the challenge of problem solving. I also really liked working in small groups. I would definitely take a class like this again. Would be nice if the grant paid for the instructor's teaching time. I thought they deserved it. As much as I enjoyed the course, if it was costly, I am not sure I would take it. The material was really helpful, but probably would not increase my productivity as a small animal vet."
"Really liked this course- it was very different from usual CE. Was more like vet school. Learned a lot and will definitely change the way I think about scientific information, in both the veterinary format, and in life/news."
"Not at this time."

of EBVM experts who would review the papers, develop a rubric for

evaluating the critiques, and develop a method of grading those critiques. We are mindful of the fact, however, that participants mentioned repeatedly that they did not have sufficient class preparation time even for reading assignments and viewing video clips, and we wonder therefore whether an exercise such as this would be feasible.

Comparing the answers on the pre- and post-course tests, the proportion of participants with correct responses on the post-course test was equal to [$n=3$] or greater than [$n=9$] the proportion of participants with correct responses on the pre-course test. For only one question — on Baye's Theorem — was this difference significant when considering each comparison independently; had we corrected for multiple comparisons this would not have been the case. We believe, therefore, that post-course test performance by participants was due to an overall improvement in understanding statistical and epidemiological concepts and not to any particular topic that was covered.

We tested the null hypothesis that completing the CE module would have no measurable impact on participating veterinarians' clinical practice by requesting a subjective evaluation of their level of Information Wizardry on the pre- and post-course test, and also by asking if they thought having taken the course will change the way they read the veterinary medical literature and the way they practice medicine. We measured a large shift in the level of Information Wizardry from before to after the course (Table 1). The mean score for participants' expectations that having taken the course would change the way they read veterinary medical literature was 4.42; the mean score for their expectations that having taken the course would change the way they practiced veterinary medicine was 2.67. Judging from participants' open-ended comments, they felt strongly that having taken the course would permit them to be more critical of what they read, but they were less sure of how that would translate into clinical practice. This may have been because participants were considering changes to practice that they'd make on their own, when in fact comments indicated that this was not likely to be a decision taken on one's own. This finding highlights the fact that improved evidence-based practice must be a goal of a community of veterinarians rather than a goal of an individual practitioner.

Now that more than three months have passed since the course, we have contacted course participants to ask the same questions, but modified to ask whether having taken the course *had* changed the way they read the literature and the way they *had* practiced veterinary medicine in the four months since the course concluded. This information will be added to an addendum to this report.

Participants' reported very positive experiences with the course although the mean score for having sufficient time to prepare for classes was slightly lower than it was for other course features. Instructors purposefully allowed for 2-3 weeks between classes to give busy participants adequate time to prepare for subsequent classes but even this amount of time seemed insufficient to some participants. By building even more time in between classes instructors lose the ability to make the best use of spacing techniques. Insufficient pre-class preparation by some participants translated into instructors' observations that this hindered class discussions at times. The concept of a flipped classroom — one that these participants had not been exposed to in their veterinary medical education — can only succeed if participants are well-prepared for class and engage actively in discussions with instructors and fellow students. For this reason, the issue of what con-

stitutes adequate class preparation time is crucial to the success of the flipped classroom model and is a priority to be addressed.

Quizzes at the beginning of each class are often employed — as was the case with this course — to encourage participants to be prepared, but in this case quizzes were used to help participants assess their own understanding of important concepts, and were neither graded nor shared with instructors. It seems unlikely that veterinarians who participate voluntarily in CE courses would take kindly to graded quizzes but we might have asked participants to hand in their quizzes without identifiers so that we could have assessed pre-class preparation ourselves.

The main criticism of the course was that it appeared disorganized at times. We believe this is not uncommon for a course that is given for the first time, and because we used a flipped classroom model we relied heavily on participants' preparation to ensure smooth course implementation.

Participants indicated that they would not be interested in taking a course such as this if it did not incorporate a great deal of face-to-face discussion, a learning format that was universally noted to be one of the best features of the course. This calls into question whether such a course could be implemented successfully online without simultaneously incorporating a significant amount of in-class interaction.

We note a few important limitations of this project. Perhaps the most important is that by our own design we were limited in our ability to measure both hypotheses, the first because we did not devise a way to assess participants' ability to directly critique the veterinary medical literature (we had participants demonstrate their understanding of concepts in pre- and post-tests, but these were indirect measures of ability to critique the veterinary medical literature), and the second because apart from self-report, we are not aware of any universally-accepted measures of EBVM's impact on veterinary medical practice (as there is in human medicine).

A second limitation is that course participants likely constituted a select group of individuals — veterinarians who were highly motivated to learn more about EBVM (and less put-off by statistics and epidemiology) and, judging from our own experiences, unlike most second-year veterinary medical students, who are required to take courses in biostatistics and epidemiology.

A third limitation is that the final number of course participants was quite a bit smaller than we had anticipated — 12 compared to 40, which limited our ability to detect smaller differences in performance on pre- and post-course tests. The smaller number of students allowed for greater individual attention to each student, but it had the limits noted above. Unpaired and paired t-tests on the mean difference in percent of correct answers were both accompanied by high standard deviations which might have been smaller had we recruited more course participants.

Recommendations

First. Course instructors feel that the course was very valuable and should be repeated. We have ideas for how the course might be modified for the future. For one, we doubt that this course should be made into online modules based on participants' recommendations. Participants strongly felt that the course required active, real-time participation on the part of instructors and participants.

Despite the limits of some participants not completing the as-

signed homework prior to the next class, we feel strongly that the flipped classroom approach was successful and would recommend it for future courses. Also, course instructors and participants felt that the material was too much even for the 12 hours of the course.

One suggestion might be to offer the course in two or three 12-hour modules (Information Wizardry I, Information Wizardry II and possibly Information Wizardry III), over the course of the summer, with participants able to sign up for one or more of the modules, according to their interest in the topics to be covered during the various sessions. Ideally, participants would sign up for all two or three modules. Offering the modules over two successive summers might provide students with greater flexibility to take them over a longer period. Breaking the material into two or three modules might also alleviate some of the perceived heavy burden of too much assigned homework prior to the next class, allow a fuller discussion of all concepts that may have seemed rushed, and allow for participants to critique veterinary medical papers prior to the last class.

Second. We are skeptical about incorporating this course into conventional CE courses, such as those offered over a two-day period by the MVMA four times a year. Several participants stated that this CE course differed from the usual CE course primarily because it required them to directly participate in many ways, whereas during the typical CE course they are lectured at, and participation by attendees is usually limited.

We have concerns about teaching the course in this format: compressing the information into a single two-day CE course would not work, and abandoning the flipped classroom approach would mean that other ways of promoting class participation would need to be explored. If the course could be broken into three modules, for instance, and each of the three modules were offered during one of the two-day CE courses, it might be possible. Still, doing so would require the need to explore other ways to encourage class participation.

Third. At Tufts Medical School, there is a Center for Information Mastery[7]. The Center has staff who teach Evidence Based Medicine (EBM) concepts to students and clinicians, and they work with other faculty and clinicians to incorporate the teaching of EBM to medical students throughout their four years. For the Medical School, teaching of the concepts is fully incorporated into the curriculum, and is separate from required courses on biostatistics and epidemiology.

Here is a brief description of the Center's goal for medical students from its website:

“Information Mastery is one of nine key themes that run through all four years of the medical curriculum. In this way, the concepts and practices of information mastery and evidence-based medicine are incorporated in both didactics and on clerkships.”

We strongly feel that a similar Center for Veterinary Information Wizardry, with a focus exclusively on EBVM, should be created at veterinary schools across the country. As is, most veterinary schools offer biostatistics and epidemiology in second-year courses, and some may offer an additional course that focuses on concepts of EBVM. Some of the concepts introduced in these courses may be emphasized in additional courses, problem-based learning sessions, clinics, and other venues.

Still, incorporating concepts of EBVM fully throughout the veterinary curriculum should be conscientious and systematic. In private, some faculty and clinicians have suggested to us that they don't feel comfortable enough with statistical and epidemiological concepts to teach them to students. Having Center staff assist faculty and clinicians in considering ways to incorporate principles of EBVM would help to involve all faculty in the teaching of principles of EBVM.

However, just as the Medical School has agreed to have Information Mastery and the teaching of EBM as one of the core themes of the medical school curriculum, for the teaching of EBVM to succeed at veterinary schools, it must be adopted by the schools as a core theme of the four year veterinary medical school curriculum.

In addition, a Center for Veterinary Information Wizardry would serve as a platform for teaching CE courses to practicing clinicians. CE courses could be taught to clinicians by Center staff, and the Center would serve as an ongoing resource for practicing clinicians.

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List of Appendices

- A. Flyer advertising the CE course, Information Wizardry
- B. Course syllabus
- C. Pre- and post-course tests
- D. Qualtrics survey
- E. Class exercises